SITE INSPECTION - ANALYTICAL RESULTS REPORT

PAVILLION AREA GROUNDWATER INVESTIGATION SITE
Pavillion, Fremont County, Wyoming

CERCLIS ID# WYN000802735

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1.0 INTRODUCTION

This Analytical Results Report (ARR) for the Pavillion Area Groundwater (GW) Investigation site (CERCLIS ID# WYN000802735) in Fremont County, Wyoming, has been prepared to satisfy the requirements of Technical Direction Document (TDD) No. 0901-01 issued to URS Operating Services, Inc. (UOS) under the U.S. Environmental Protection Agency (EPA) Region 8 Superfund Technical Assessment and Response Team 3 (START 3) Contract No. EP-W-05-050. This report has been prepared in accordance with the EPA "Guidance for Performing Site Inspections under CERCLA," Interim Final, September 1992, and the "Region 8 Supplement to Guidance for Performing Site Inspections under CERCLA" (U.S. Environmental Protection Agency (EPA) 1992; EPA 1993). Field activities were conducted from March 2 through March 6, 2009 and May 14 through 15, 2009, in Pavillion, Wyoming. Field activities followed the Site Inspection (SI) format, applicable UOS Technical Standard Operating Procedures (TSOPs), and the Generic Quality Assurance Project Plan (QAPP) (URS Operating Services, Inc. (UOS) 2005a; UOS 2005b).

This ARR is intended to be used in conjunction with the Field Sampling Plan (FSP) (UOS 2009), see Appendix E.

1.1 OBJECTIVES

The objective of the Pavillion Area Groundwater Investigation focused Site Inspection (SI) is to gather information and data for the evaluation of this site with regard to the EPA's Hazard Ranking System (HRS) criteria. The site will be evaluated using analytical data provided in this ARR for an overall characterization of the site. The specific objectives of this SI are to:

- Determine if contamination is present in domestic wells in the study area;
- Determine contaminant characteristics;
- Determine the potential impacts to public health and the environment from any contaminants identified in domestic wells.

1.2 FIELD ACTIVITIES

During the March 2009 and May 2009 sampling events, 39 separate groundwater samples were collected at residential and municipal wells to evaluate the presence of contamination at the site. The details of the groundwater sampling event are located in Section 4.0.

Field activities consisted of collection of 37 residential well water and 2 municipal well water samples in Pavillion, Wyoming. Field activities were conducted during March 2 through 6, 2009 and May 14 and 15, 2009. Samples were analyzed for all or some of the following parameters: Volatile Organic Compounds (VOCs), Semi-Volatile Organic Compounds (SVOCs), Target Analyte List (TAL) total metals, pesticides, polychlorinated biphenyls (PCBs), microbacteriological parameters, anions, and petroleum hydrocarbons including Total Purgable Hydrocarbons (TPH), Gasoline Range Organics (GRO), Total Extractable Hydrocarbons (TEH), and Diesel Range Organics (DRO). Samples from all 39 properties were analyzed for VOCs, SVOCs, TAL total metals, pesticides, anions, and PCBs; samples from 15 properties were analyzed for polar compounds, SVOC Tentatively Identified Compounds (TICs), anion and groundwater chemistry, and methane; samples from 12 properties were analyzed for TPH, GRO, TEH, and DRO; and samples from 5 properties were analyzed for bacteriological parameters.

In addition to the samples described above, one sample was collected through a carbon trap filter. Water was run through the filter for 24 hours with an approximate volume of 780 gallons. At the conclusion of the sampling period, the carbon was collected in a sample jar and filled completely with sample water. The carbon/ water sample was analyzed for low-level SVOCs.

2.0 SITE DESCRIPTION

2.1 SITE LOCATION

The Pavillion Area GW Investigation site is located near Pavillion, Wyoming, in Fremont County (Figure 1). The site is a rural community situated northeast of Pavillion in the Wind River Basin and is centered approximately where several complaints of foul odor and taste in domestic water wells have been raised by residents. This project was funded through the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and therefore certain criteria must be met and

certain conventions must be observed. While CERCLA allows for groundwater plumes, it is generally based on a point source or sources, exposure pathways and targets. Therefore a plume with no documented source or location presents a poor fit. The study area is defined per HRS criteria as a four radius circumscribed around the "site". The site is centered in the Southwest quarter of Section 2, T. 3 N., R. 2 E. The latitude is 43°15'37.533" north and the longitude is 108°36'59.698" west. Land use surrounding the site is rural, with some residential properties located among fields used for agriculture and oil and gas production.

2.2 SITE HISTORY

Domestic well owners in the Pavillion area have filed complaints and have reported a foul odor and taste in their groundwater. Some domestic well owners suspect the foul odor and taste originates from oil and gas well activity in the area.

2.3 SITE CHARACTERISTICS

2.3.1 Physical Geography

The Pavillion Area GW Investigation site is located in the Wind River Valley, which is the major regional topographic expression. The valley is located in central Wyoming, and is approximately 200 miles long by 100 miles wide, covering an area of approximately 11,700 square miles (Fox and Dolton, 1995). The site is at an elevation of approximately 5,463 feet above mean sea level and the terrain at the site slopes gently to the south (U.S. Geological Survey (USGS) 1958). The site is located in a sparsely populated rural area. The predominant vegetation in the area is a mixture of dryland grasses and shrubs (UOS 2008).

2.3.2 Geology and Hydrogeology

Geology at the site will impact the investigation due to its complexity. Groundwater in the area is also complex and varies with location, elevation, and geologic unit. The USGS reports more than thirty water-bearing formations in the Wind River Basin, including two regional aquifers and one major aquifer (Zelt et al 1999). The Wind River Basin (WRB) has

a complicated structure created by uplifting, folding, and faulting. The Wind River aquifer is the principal source of domestic and stock water at the site.

The site is located in the Wind River Basin, a structural and sedimentary basin, in central Wyoming, resulting from the Larimide Orogeny, which began in the early Cretaceous Period and lasted until the Eocene Epoch. The basin is bounded by upfolded and faulted mountain ranges resulting from the Laramide uplifts. These ranges include the Owl Creek and Bighorn Mountains to the north, the Wind River Range to the west, the Granite Mountains to the south, and the Casper Arch to the east. (USGS 1969, 2006).

In the Wind River Basin, the major stratigraphic units exposed at the surface are Cretaceous, Tertiary, and Quaternary in age.

The Cretaceous units include the Cody Shale, a dull gray shale, with gray siltstones and fine grained sandstones, and the Mesaverde Formation, a light colored massive to bedded sandstone with gray sandy shale and coals beds present.

Tertiary aged units include the Wind River, Fort Union, and Indian Meadows Formations. The Wind River Formation is the dominate outcrop present in the Wind River Basin and is exposed over most of the central portion of the basin. This formation is described as a red and white claystone and siltstone unit containing a lenticular coal unit in the center of the formation, and mostly nontuffaceous except near the top (Love and Christiansen1985). The thickness of the Wind River formation varies from just a few meters at the basin margin, to several thousand meters thick in the northern part of the area (Seeland 1978). The Indian Meadows Formation is described as a red claystone to sandstone with limestone present; the unit also contains Paleozoic boulders and Mesozoic rocks, probably resulting from glaciations (Love and Christiansen 1985). The Indian Meadow is absent along the southwestern side of the basin, and maybe thousands or more meters thick in the subsurface along the north side of the basin (Seeland 1978). The Fort Union Formation, the least abundant unit present in the basin, is described as a brown to gray sandstone with gray to black shale and thin coal beds.

Along with the previous mentioned formations, the basin contains various Quaternary deposits including river alluvium, gravel pediment, and fan deposits; and Pleistocene glacial

deposits (Love and Christiansen 1985). Along the northern edge of the basin the Fort Union is 2500 meters thick, along the west and south sides of the basin the formation ranges in thickness from 50 to 350 meters (Seeland 1978).

The Wind River Basin has a complicated structure created by the uplifting, folding, and faulting of the Larmide Orogeny. Various thrust faults run the length of the basin along the north and northeast boundaries. A large amount of faulting is also present in the north central to northeastern part of the basin and in the south part of the basin near the Granite Mountains (Love and Christiansen 1985). The complex geologic structure and rock formations have resulted in many structural and stratigraphic traps for hydrocarbons; consequently, drilling for natural gas and oil is common in the area (Fox and Dolton 1995). Detailed subsurface geology information is not readily available. In addition to the hydrocarbon production in the basin, uranium deposits are also along the south and southeast basin margins (Seeland 1978, Soister 1968). Many of the lower Eocene aged strata are radioactive in the southeastern part of the basin; however, they only contain uranium minerals in a few localities (Keefer 1965).

Water-yielding, Tertiary aged formations in the basin include the White River, a highly permeable and productive unit, yielding between 1 and 1100 liters per minute, with a maximum reported at 3200 liters per minute; Tepee Trail, which yields small amounts of water and is a confining layer; the Wagon Bed, which yields small amounts of water, but is not considered an aquifer; the Wasatch for which water yield is unknown; and the Wind River, which represents a major aquifer in the basin and yields water between 4 and 11000 liters per minute. These formations contain local artesian zones, are the principal source of domestic and stock water on the Wind River Reservation, and are the major source of industrial water in the southern part of the basin. The Willwood and Fort Union Formations yield small amounts of water, although the Fort Union isn't believed to be suited for domestic use. The Aycross and Indian Meadows Formations represent confining layers within the Tertiary units. A majority of the groundwater used in the region comes from the younger aquifers, mostly due to the depth of the aquifers (Zelt et al 1999).

Cretaceous aged units, are generally not used for groundwater supply, due to their depth, and the lower permeability present in many units. Creataceous units include the Lewis Shale, which is unsuitable for domestic use; Mesaverde Formation, which has artesian flow reported by numerous petroleum tests within the basin; and the Cody Shale which yields meager, poor quality amounts of water. The Frontier Formation produces poor quality water in places; however, the upper portion of this unit represents a regional aquifer with the lower portion representing a confining layer. Domestic wells from this aquifer have produced from 19 to 570 liters per minute. Clovery Formation is the last Cretaceous aquifer and produces artesian flow from 4 to 95 liters per minute. Thermopolis Shale, Mowry Shale, and the Meeteetse Formation represent confining layers from this age group (Zelt et al 1999). Jurassic and Triassic aged aquifers include the Morrison Formation, a sandstone that may produce enough water for domestic use, the Gypsum Spring, Nugget Sandstone, Chugwater Dinwoody, and Goose Egg Formations, all of which produce small amounts of water of varying qualities. The Sundance Formation which represents other regional aquifers of the Wind River Basin, provides shallow stock and domestic wells from 4 to 95 liters per minute. The Morrison, Sundance, and Chugwater Formations along with the Permian aged Phosphoria formation, see below, are used in small areas of the basin for the groundwater supply (Zelt et al 1999).

The Permian aged Phosphoria Formation is a highly productive formation in areas where it has fractures, with wells yielding up to 3800 liters per minute. The Permian and Pennsylvanian aged Tensleep Sandstone aquifer system is made up of many units, of which the Tensleep Sandstone is the uppermost and has good permeability. The unit is very productive where fractured, and the water is under confined conditions producing flows from 4 to several hundred liters per min. Where the unit is fractured, flow yields greater than 3800 liter per minute are possible. The Amsden Formation is the middle unit present in this aquifer system, and has properties very similar to the Tensleep Sandstone. The next unit in this aquifer system is the Madison Limestone, which has poor permeabilities except were fractured or where saturated caverns are present. The Limestone is water producing through out the Wind River Basin with yields ranging from 4 to several hundred liters per minute. The rest of the aquifer system is made up of the Darby Formation and the Bighorn Dolomite which typically are confining layers however in the WRB there are numerous joint controlled springs which yield water (Zelt et al 1999).

The Cambrian aged aquifers begin with the Gallatin Limestone, a confining layer which yields small amounts of water along joints and fractures. The Flathead Sandstone, a dull red quartizitic sandstone, represents the major aquifer in the Wind River Basin. The water is semi-confined to confined and produces yields of 4 to 19 liters per minute. The Sandstone represents an excellent source of groundwater; however it is relatively undeveloped due to the availability of shallower groundwater sources (Zelt etal, 1999).

2.3.3 Hydrology

Surface water and runoff generally flows south from the site to Five Mile Creek then to the Boysen Reservoir. The annual mean flow of the Five Mile Creek for the year of 2007 was 120 cubic feet per second (cfs) and the highest flow recorded was 253 cfs in 1999 (USGS 2008).

2.3.4 Meteorology

The climate of Wind River Valley is characterized as semiarid continental, with an annual mean precipitation of approximately 11.5 inches and an annual net precipitation of slightly more than 1 inch (University of Delaware 1986). The two-year 24-hour rainfall event for the area is approximately 1.5 inches (Dunne, Thomas and Luna B. Leopold 1978).

3.0 PATHWAY CHARACTERIZATION

3.1 SOURCES (WASTE CHARACTERISTICS)

No direct source of groundwater contamination has been identified at ground surface or within two feet of ground surface. As such the source (as defined by HRS) has been defined as a groundwater investigation of undetermined size. There are numerous gas wells, gas well waste pits, and agricultural chemical storage areas that could be potential sources of contamination in the study area.

Natural gas and oil wells located in the vicinity of the residential properties are a potential source of potential contamination at the site. According to an EPA study list of drilling fluid components assembled by the EPA (EPA 2008), several different types of drilling fluids, containing several

hazardous compounds, are used to install gas wells. Additionally, The Endocrine Disruption Exchange (TEDX) has compiled a list of chemicals used in natural gas development in Wyoming. While the TEDX list is comparable to the EPA Study List, it adds several metals that maybe found in compounds used in gas well installation and are as follows: aluminum oxide, arsenic, cadmium, copper, iron, lead, mercury, nickel, vanadium and zinc. See Appendix C for the EPA Study List of Drilling Fluid Compounds and TEDX List of Chemicals Used in Natural Gas Development in Wyoming.

The Superfund Chemical Data Matrix (SCDM) is a list of benchmark values used in the evaluation of National Priorities List (NPL) sites under the Hazard Ranking System (HRS). The following chemicals are found in both the EPA Study List and the TEDX list have and a SCDM associated with them as well:

TABLE 1

Hazardous Chemicals in Drilling Fluids with a SCDM Value

Chemical Name	SCDM – Drinking Water (1/28/2004) Concentration in ug/L (MCL)
Benzene	5.0
Toluene	1,000
Ethyl benzene	700
Xylene	10,000
Naphthalene	20
1-Methylnapthalene	20
2- Methylnapthalene	150
Fluorenes	1500
Ethylene glycol	73,000
Formic acid	73,000
Methanol	18,250
Ethylene glycol monobutyl ether	18,000
Aluminum oxide	36,000
Arsenic	0.057
Cadmium	5
Copper	1,300
Hydrogen sulfide	10
Iron	11,000
Lead	15
Mercury	0.63
Nickel	730
Vanadium	36
Zinc	11,000

MCL Maximum Contaminant Level (US EPA Drinking Water Regulations)

Analyses were also performed to determine if agricultural or industrial contaminants were present in the wells.

3.2 SURFACE WATER PATHWAY

Topography of the site slopes to the south and east. The surface water overland drainage flows off the site mainly in the southeasterly direction 975 feet to the Five Mile Creek where the in-water segment of the surface water pathway begins and then ends 15 miles downstream.

The annual flow rate of Five Mile Creek is 120 cubic feet per second (cfs) and the creek is considered a fishery.

Four miles of the fifteen-mile target distance limit along Five Mile Creek consists of wetlands (Figure 2). The wetlands start approximately one-quarter mile downstream of the site with Palustrine Shrub Scrub and the remainder of the wetlands consists of Palustrine Emergent land with a scattering of Palustrine Scrub Shrub (U.S. Fish and Wildlife Service (USFWS) 1998).

No drinking water intakes are documented along the 15-mile target distance limit.

No electronic floodplain information could be located at the time of the preparation of this report.

Five Mile Creek is used for recreational fishing. The following species of fish can be found in Five Mile Creek: Burbot, Flathead Chubs, Lake Chubs, White Suckers, and Long-nose Dace. With the exception of the Burbot, these fish are not typically eaten by humans. This creek is considered a fishery by Wyoming Standards.

In accordance with the final FSP, dated January 2009, no surface water samples were collected during the course of the March 2009 sampling event (UOS 2009).

3.3 GROUNDWATER PATHWAY

The preponderance of residents in the study area obtain their drinking water from private domestic wells. The Wyoming State Engineer's Office has records of approximately 53 private domestic wells

within the four-mile radius of the site. The average number of persons per household in Fremont County, Wyoming, is 2.30 (U.S. Department of the Interior, Bureau of the Census (U.S. Census Bureau) 2000). Assuming that each domestic well serves one household, the total number of residents using groundwater within the four-mile radius of the site can be calculated to be approximately 123 people. The data from the Wyoming State Engineer's Office website does not provide information on the current status of each well within the four-mile radius (Wyoming State Engineer's Office 2008).

There are two domestic primary target wells located within one-half mile of the site that serve five people (Wyoming State Engineer's Office 2008). Currently no conclusive analytical data are available for these wells.

For HRS purposes, the nearest well to the site is within a quarter mile radius of the source (approximate center of the complaints) and the well is located at 212 Powerline Road. The depth of the domestic well is 210 feet and serves two people.

The town of Pavillion, Wyoming, located approximately five miles northwest of the study area center has eight municipal wells that supply water to residents. None of the eight municipal wells that supply the town of Pavillion are in the study area.

Within the two mile radius of the site there are eight stock wells used for ranching purposes (Figure 2).

TABLE 2
Domestic Wells within a Four-Mile Radius

Radius	Number of Persons served by Domestic wells
0 - 0.25	2
0.25 - 0.50	3
0.50 - 1.0	5
1.0 - 2.0	18
2.0 - 3.0	37
3.0 - 4.0	58
Total	**123**

3.4 SOIL AND AIR EXPOSURE PATHWAYS

HRS requires the definition of a "site". Since there was no documented source of contaminants in the study area, the "site" is defined as the gas well closest to the center of the study area. A gas wellhead is situated on this site. This wellhead has very little vegetation and has a loose gravel drive surrounding the it. The site access is not restricted and easily accessible to the public. There are no residents living on site or within 200 feet. One to 2 workers are on site frequently. Approximately 59 residents live within the one-mile radius of the site (i-cubed 2008). The residence nearest to the site is about 975 feet southeast of the site at 212 Powerline Road.

There are no terrestrial sensitive environments identified within 200 feet of the site (UOS 2008). The site is located in a rural area on the Wind River Basin in north central Fremont County. There are approximately 2 residents located within a quarter-mile radius of the site, and a total of 161 people within the four-mile radius. The site has very little to no vegetation directly surrounding the gas well wellhead and is easily accessed by the public.

An average of 2.3 people occupy each residence in Fremont County (U.S. Census Bureau 2000).

There are sensitive terrestrial environments identified within the four-mile radius of the site. There is a State Wildlife Management Area within the one to two mile radius of the site and another State Wildlife Management Area is located within the three to four-mile radius of the site.
There are 1,212 acres of wetlands located within the four-mile radius of the site. Over 1,000 acres of wetlands are part of the Ocean Lake, which is also designated as a State Wildlife Management Area.

TABLE 3
Population and Wetlands within Four Miles of the Site

Distance from Site	Population (# of persons)	Wetlands (acres)
On Site	0	0
0 - ¼ Mile	2	0
>¼ - ½ Mile	9	0
>½ - 1 Mile	7	0
>1 – 2 Miles	39	111
>2 – 3 Miles	51	45
>3 – 4 Miles	53	1,056
Total Within 4 Miles	161	1,212

Source: National Wetlands Inventory.

See the table below for a State of Wyoming Game and Fish list of endangered and threatened species found in Fremont County (WYGF 2008).

TABLE 4
Threatened and Endangered Species in Fremont County

Species	Scientific Name	Status
Brown Pelican	*Pelecanus occidentalis*	Endangered
Wood Stork	*Mycteria americana*	Endangered
Bald Eagle	*Haliaeetus leucocephalus*	Threatened
Whooping Crane	*Grus americana*	Endangered
Piping Plover	*Charadrius melodus*	Endangered
Least Tern	*Sterna antillarum*	Endangered
Passenger Pigeon	*Ectopistes migartorius*	Extinct
Gray Wolf	*Canis lupus*	Threatened
Grizzly Bear	*Ursus arctos*	Threatened
Black-footed Ferret	*Mustela nigripes*	Endangered
Canada Lynx	*Lynx canadensis*	Threatened

Source: State of Wyoming Game and Fish 2008.

In accordance with the final FSP, dated January 2009, no soil or air samples were collected during the course of the March 2009 sampling event.

4.0 FIELD ACTIVITIES

Field activities consisted of collection of 37 residential well water and 2 municipal well water samples in Pavillion, Wyoming. In order for a property to be included in the sampling event, the property owner must have volunteered for inclusion and signed a property consent for access form. As budgetary constraints and time did not allow all properties to be evaluated for all compounds of concern, the analytical parameters were selected for each location based upon a questionnaire completed by the study participants. The questionnaire addressed changes in water quality, presence of hydrocarbon smell or sheen on water, abnormalities in taste or appearance of water, and whether problems warranting abandonment or well failure occurred at any nearby wells. The answers to the questionnaire were used to prioritize wells for certain analytical parameters. Based on the answers of the questionnaire, water samples were analyzed for all or some of the following parameters: Volatile Organic Compounds (VOCs), Semi-Volatile Organic Compounds (SVOCs), Target Analyte List (TAL) total metals, TOFF pesticides, polychlorinated biphenyls (PCBs), microbacteriological parameters, anions, and petroleum hydrocarbons including Total Purgable Hydrocarbons (TPH), Gasoline Range Organics (GRO), Total Extractable Hydrocarbons (TEH), and Diesel Range Organics (DRO). Samples from all 39 properties were analyzed for VOCs, SVOCs, TAL total metals, pesticides, anions, and PCBs; samples from 15 properties were analyzed for polar compounds, SVOC TICs, anion and groundwater chemistry, and methane; samples from 12 properties were analyzed for TPH, GRO, TEH, and DRO; and samples from 5 properties were analyzed for bacteriological parameters. In addition to the samples described above, one sample was collected through a carbon trap filter. Water was run through the filter for 24 hours with an approximate volume of 780 gallons. At the conclusion of the sampling period, the carbon was collected in a sample jar and filled completely with sample water. The carbon/ water sample was analyzed for low-level SVOCs.

At most locations, START personnel ensured three well volumes had been purged prior to sample collection. Three exceptions to three purge volumes occurred at wells where a three volume purge was not feasible due to a large volume of water in the casing or at wells that ran dry during purging. The depth of wells PGDW29 and PGDW36 were unknown (no data from the Wyoming State Engineers Office (SEO) and well owners did not know depth) therefore a three volume purge was uncertain. Since these wells serve as a primary drinking water source for the households, constant use provided a sufficient purge and a full purge of three volumes was not necessary. For well PGDW05 a full purge of three casing volumes was not possible as the well ran

dry before the purge could be completed. This was verified by pumping the well to failure after samples were collected (the well produced 45 gallons of water before running dry).

At the conclusion of well purging, water parameters; including temperature, conductivity, and pH, were measured, until three consecutive readings were within 10% of one another for all parameters. Upon stabilization of parameter readings, START personnel collected samples for analysis for parameters selected for the property. All samples were collected as close to the groundwater pump as possible, in order to minimize contamination that may be introduced by piping, hoses, or related components and to eliminate the possibility that samples had been filtered prior to collection. Additionally, a GPS reading was collected at each location. Samples were placed in a cooler on ice, labeled, securely packed under chain of custody, and shipped according to the appropriate holding times.

Quality Assurance/Quality Control (QA/QC) samples included the collection of two duplicate samples, two Matrix Spike/ Matrix Spike Duplicates (MS/MSD), one trip blank for each cooler shipped containing VOC samples, and one rinsate blank for the carbon trap.

4.1 MARCH 2009 SAMPLING EVENT

Sampling activities for the initial sampling event were performed from March 2, 2009 through March 6, 2009. Samples from the initial sampling event were shipped via Federal Express or courier service to one of three laboratories, depending upon the analysis required: petroleum hydrocarbon and microbiological samples were shipped to Energy Laboratories, Inc. located in Billings, Montana; and anion samples were shipped to the USEPA Region 8 Laboratory in Golden, Colorado; TAL total metals, VOCs, SVOCs, pesticides, and PCB samples were shipped to a Contract Laboratory Program (CLP) laboratory (see Appendix E for specific methods).

4.2 MAY 2009 SAMPLING EVENT

Sampling activities for the secondary sampling event were performed from May 14, 2009 through March 15, 2009. Samples from the secondary sampling event were shipped via Federal Express to Energy Laboratories, Inc. located in Billings, Montana (see Appendix E for specific methods).

5.0 LABORATORY DATA ANALYSIS

Samples were analyzed at four different laboratories: Energy Laboratories, Inc. located in Billings, Montana; USEPA Region 8 Laboratory in Golden, Colorado; KAP Laboratories in Vancouver, WA; and Liberty Analytical in Salt Lake City, UT. See section 5.0 for specific tests at specific laboratories. Groundwater sample analytical results are reported in Tables 7 through 14. Laboratory data and validation reports are presented in Appendix A.

5.1 MARCH 2009 SAMPLING EVENT

The VOC contaminant methylene chloride was detected in two groundwater samples at levels above its Method Detection Limit (MDL), but below the Contract Required Quantitation Limit (CRQL). However, methylene chloride is a common laboratory contaminant (it is used in environmental sample preparation) and these detections should be disregarded as laboratory contamination. SVOC contaminants including caprolactam, dimethylphthalate, and bis(2-ethylhexyl)phthalate were detected in groundwater samples at levels above their respective non-detect values. All three of these SVOC compounds are found in the electronics and piping of groundwater wells and are likely non-significant. None of the PCB contaminants analyzed for were detected at levels above their detection limits. The organo-chlorine pesticides beta-BHC and endrin aldehyde were detected in groundwater samples at levels above their respective non-detect values, however close examination of the raw data indicates that these detections are in fact false positives and should be disregarded. Pesticide analysis by SW-846 8081B uses two columns that have different retention times for each compound. One column is used for analytical quantitation and the other is used for analytical compound confirmation. To be considered a valid detection the compound peak retention time must fall within a certain percent of the same compound's retention time in the calibration. Neither pesticide had a valid detection on the confirmation column. See Table 9 for organic sample results.

Samples were selected for TPH, GRO, TEH, and DRO analysis based on the results of a survey conducted with well owners that had agreed to have their drinking water sampled (see section 1.1 for details). Samples selected for TPH, GRO, TEH, and DRO analysis included: PGDW04, PGDW05, PGDW10, PGDW20, PGDW22, PGDW23, PGDW36, and PGDW38. TPH was detected in samples PGDW05 (26 µg/L) and PGDW30 (25 µg/L) at levels above the non-detection limit in groundwater samples. Sample PGDW05 had a visible sheen on the water purged from the well (see photolog

Appendix B); START personnel collecting the sample reported that the purge water had a hydrocarbon odor. Petroleum hydrocarbons were detected at levels above the non-detect limit in samples PGDW05 and PGDW30 at 26ug/L and 25ug/L respectively. See Table 10 for petroleum hydrocarbon results.

Samples were selected for microbacteriological analyses based on the results of a survey conducted with well owners that had agreed to have their drinking water sampled (see section 1.1 for details). Samples selected for microbacteriological analyses included: PGDW04, PGDW05, PGDW20, PGDW22, and PGDW23. HPC bacteria, iron related bacteria, and sulfate reducing bacteria were detected in some of the groundwater samples (see Table 11).

Metals contaminants including, antimony, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, lead, manganese, nickel, selenium, silver, thallium, vanadium, and zinc were detected in the groundwater samples at levels above their respective non-detect value.

Anion and water chemistry analysis data revealed exceedances for Secondary Drinking Water Standards in most of the sampled well results for sulfate and one well, PGDW22, exceeded the Primary Drinking Water Standards for Nitrate (see Table 12).

Samples were selected for methane analysis based on the results of a survey conducted with well owners that had agreed to have their drinking water sampled (see section 1.1 for details). Samples selected for methane analysis included: PGDW04, PGDW05, PGDW07, PGDW10, PGDW17, PGDW20, PGDW21, PGDW22, PGDW23, PGDW26, PGDW29, PGDW30, PGDW32, PGDW35, and PGDW38. Methane was detected above the reporting limit in 8 of the samples (See Table 13).

All samples were analyzed for Tentatively Indentified Compounds (TICs) in CLP SVOC and VOC analyses. Additionally, samples were selected for low-level SVOC TIC analysis at the Region 8 Laboratory based on the results of a survey conducted with well owners that had agreed to have their drinking water sampled (see section 1.1 for details). Samples selected for low-level SVOC TIC analysis included: PGDW04, PGDW05, PGDW07, PGDW10, PGDW17, PGDW20, PGDW21, PGDW22, PGDW23, PGDW26, PGDW29, PGDW30, PGDW32, PGDW35, and PGDW38. Both sets of TIC data were combined to create a stronger dataset for this study. Mass Spectra for unknown peaks acquired during the GC/MS analyses are compared to a NIST library containing the Mass

Spectra for several million organic compounds. If a match is found for a compound that has a greater than 95% probability of being correct, the compound is reported as a TIC. While the TIC has little value as a quantitative tool (these are compounds not included in the calibration), they are invaluable as a tool for identifying compounds that are not on the routine analysis list.

Compounds that represent method artifacts (column bleed, peaks that are found in blanks, etc) were removed from the TIC results. There were no VOC TICs detected. The remaining TICs fall into two groups: compounds that likely come from plastics, electronics, and PVC solvents in the well and compounds of potential interest. Compounds that can be attributed to well components include: 2,4-bis(1-phenyl)-phenol and Bisphenol A (plasticizers from degrading plastic); Terpineol and Limonene (common degreasers and cleaning products); and 5-Hydroxymethyldihydrofuran (a compound found in PVC cement). Compounds of interest include: Adamantanes (a naturally occurring hydrocarbon found in crude and gas condensate); and 2-Butoxyethanol. 2-butoxyethanol is one of the components listed as a foaming agent in the EPA Study List of Drilling Fluid Compounds (EPA 2008; Appendix C); it is the active ingredient in the household cleaner Simple Green as well. It is possible for 2-butoxyethanol to react with natural occurring phosphates to produce 2-butoxyethanol phosphate. The ASDTR is working with EPA Region 8 to access the toxicity of 2-butoxyethanol. See Table 14 for TIC results.

In summary, several compounds of interest were detected in the study:

- Arsenic was detected in sample PGDW25 at 34 µg/L, which exceeds the MCL of 10 µg/L;
- Petroleum Hydrocarbons were detected in samples PGDW05(26ug/L) and PGDW30 (25ug/L);
- TIC analyses revealed two compounds that might not be attributable to well components: adamantanes and 2-butoxyethanol phosphate;
- Several samples demonstrated elevated levels of methane in the study.

Many of the detections (arsenic, methane, adamantanes, 2-butoxyethanol phosphate, and caprolactum) occur in a small number of wells grouped in a relatively small area. This area may benefit from additional investigation.

5.2 MAY 2009 SAMPLING EVENT

START collected one drinking water sample from one well in Fremont County, Wyoming in May 2009. One analyte was found to exceed the secondary drinking water regulations in well PGDW39: sulfate was detected at 3980 mg/L; the Secondary Drinking Water Standard is 250 mg/L (see Table 7 for metals results and Table 12 for anion and water chemistry results).

5.3 DATA VALIDATION AND INTERPRETATION

Samples were analyzed for TAL total metals by KAP Laboratories through the Contract Laboratory Program (CLP); VOCs, SVOCs, pesticides, and PCBs were analyzed by Liberty Analytical Corporation through the CLP; for petroleum hydrocarbon and microbiological parameters by Energy Laboratories, Inc; and for anion and water chemistry parameters, methane, and SVOC low-level TICs by the USEPA Region 8 Laboratory. For sample PGDW39 all analyses were performed by Energy Laboratories, Inc. All samples were collected between March 2 and 6 and May 14 and 15, 2009. All CLP data were validated by TechLaw Inc. the remainder of the data is to be used solely for screening purposes and was evaluated by a UOS chemist. The data are acceptable for their intended use with attached qualifiers. While the data met all contractual and methodological requirements, the following issues were revealed by the data validation and review:

While the overall quality of the data was good, several SVOC compounds were rejected and flagged with an "R" qualifier due to a failure in the associated Deuterated Monitoring Compound (DMC) recovery (less than 10%). These rejected data points included 2,4-Dinitrophenol, 2-Nitroaniline, 3-Nitroaniline, 4,6-Dinitro-2-methylphenol, 4-Nitroaniline, 4-Nitrophenol, and 4,6-Dinitro-2-methylphenol in samples PGDW02, PGDW04, PGDW06, PGDW10, PGDW12, PGDW30, PGDW31, and PGDW32. Samples PGDW04, PGDW10, PGDW30, and PGDW32 were analyzed for SVOCs at the EPA Region 8 Lab with satisfactory QA/QC results and were non-detect for all of the rejected data points, while the data can not be validated as it lacks clp-forms and raw data, it

supports the conclusion these compounds may be non-detect. Additionally, samples PGDW10D and PGDW30D were field duplicates of samples PGDW10 and PGDW30 (respectively). These field duplicates were analyzed in another QA/QC batch that had acceptable results and were all non-detect for the compounds of concern. Finally, none of the compounds of concern (compounds associated with the failed DMC) are found in the EPA Study List of Drilling Fluid Compounds (EPA 2008) or the TEDX List of Chemicals Used in Natural Gas Development in Wyoming (TEDX 2008). All "R" flagged data was removed from letters to homeowners, as well as the tables in this report.

Some problems with laboratory blanks resulted in the application of additional qualifier flags. Discussion will be limited to those analytes with a potential to impact water quality or affect the HRS score of the site and analytes found in the EPA Study List of Drilling Fluid Compounds (EPA 2008) or the TEDX List of Chemicals Used in Natural Gas Development in Wyoming (TEDX 2008).

Several VOC, SVOC, and metals results were qualified with a "UJ" flag by validator indicating that the reporting limit is uncertain in those instances. Given the lack of SVOC and VOC detections in the dataset and the low-levels of the metals MDL in respect to the metals MCLs the data are still of decision-quality for the study.

Blank contamination that was less than the Contract Required Detection Limit (CRDL), but above the Method Detection Limit (MDL) resulted in the elimination of several low-level detections for metals.

All other changes to data involved the application of J, indicating the value is estimated, J- indicating the value is estimated and biased low, and J+ indicating that the value is estimated and biased high.

See Appendix A for data validation report and specific changes to qualifier flags.

5.4 DATA QUALITY ASSESSMENT

All analytical data, including logbooks, Chains of Custody (COC), and long form raw data packages, were reviewed by a UOS chemist or by third party data reviewer against the TSOP or EPA method they were generated under, and found to be acceptable for their intended use.

5.4.1 Field Analytical Data

Temperature, conductivity, and pH measurements were taken in the field using an Oakton Instruments® model PCS Testr35. The pH and conductivity were calibrated at the beginning of the day and all samples were collected within 3 hours of calibration. Logbooks were reviewed and field analytical data for all samples were found to be complete.

5.4.2 Laboratory Analytical Data

Samples sent to CLP laboratories, were validated by a third party data reviewer and are acceptable for use as qualified in the data validation report. The data validation report and laboratory data are located in Appendix A. Samples were analyzed for TAL total metals by KAP Laboratories through the Contract Laboratory Program (CLP); VOCs, SVOCs, pesticides, and PCBs were analyzed by Liberty Analytical Corporation through the CLP; for petroleum hydrocarbon and microbiological parameters by Energy Laboratories, Inc; and for anion and water chemistry parameters, methane, and SVOC low-level TICs by the USEPA Region 8 Laboratory. For sample PGDW39 all analyses were performed by Energy Laboratories, Inc. CLP data were reviewed per the USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review (NFG)and all other data were reviewed by a qualified UOS staff chemist. Data were compared to FSP DQOs as well as project requirements, and found to be of decision making quality.

5.4.3 Data Quality Indicators

Bias

Calibrations, serial dilutions, interference check samples, matrix spikes, and blanks were reviewed as possible indicators of bias in the data. Negative blank contamination was present in the laboratory data for some data points (this means some values were less than 0.0 PPM in the calibration check blank). Negative blank contamination creates a potential low bias. The soil data points have a potential high bias due to matrix effect in several metals. Potential bias is indicated by a "J-" (estimated, biased low) or "J+"

(estimated, biased high) qualifier in the data set. See Appendix A for data validation results.

Sensitivity

Some reporting limits were raised by the data reviewer due to blank problems (as discussed above). The elevated detection limits do not impact the end use of the data, because the concentrations in the affected metals are far below the action levels at the site.

Precision

Precision is monitored by instrument calibration and spike samples. All precision criteria were met with the exception of the SVOC data flagged as "R" (discussed in section 5.3).

Accuracy

All laboratory duplicates met criteria. The field duplicates had some relative percent differences (RPDs) that were greater than the 20% criteria set by the NFG. However, since all values associated with high RPDs were within 5X of the Contract Required Detection Limit (CRDL) they are considered non-significant, per NFG specifications. This variability is due to increasing error as values approach the CRDL. Overall RPD was 10.4% in the data; detailed RPD results are in the table below.

TABLE 15
Sample Duplicate Results

Analysis	Analyte	PGDW10D	PGDW10	RPD	PGDW30	PGDW30D	RPD
Anion/ Alkalinity	Alkalinity	147	147	**0.0%**	95.7	95.4	**0.3%**
Anion/ Alkalinity	Chloride	8	8	**0.0%**	16.3	16	**1.9%**
Anion/ Alkalinity	Fluoride	0.9	0.9	**0.0%**	0.9	0.8	**11.8%**
Anion/ Alkalinit	Sulfate as SO4	293	289	**1.4%**	335	331	**1.2%**

TABLE 15
Sample Duplicate Results

Analysis	Analyte	PGDW10D	PGDW10	RPD	PGDW30	PGDW30D	RPD
y							
ICP MS	Arsenic	0.13	0.13	**0.0%**	0.094	0.1	**6.2%**
ICP MS	Barium	10.9	10.9	**0.0%**	7.9	8.2	**3.7%**
ICP MS	Copper	4	3.5	**13.3%**	3.9	6.7	**52.8%**
ICP MS	Manganese	4.2	4.7	**11.2%**	3.3	1.6	**69.4%**
ICP MS	Zinc	17.7	11.3	**44.1%**	35.5	37	**4.1%**
ICP AES	Calcium	6130	6100	**0.5%**	4290	4140	**3.6%**
ICP AES	Sodium	204000	204000	**0.0%**	210000	202000	**3.9%**
Average RPD				**6.4%**			**14.4%**
Overall RPD		**10.40%**					

Representativeness

All samples were collected within a similar time frame using the same methodology, with the exception of sample PGDW39. PGDW39 should not be used for the evaluation of aquifer chemistry. There were no deviations from the Field Sampling Plan (FSP), TSOPs, or analytical methods employed to collect the data. All holding time, COC, and preservation requirements for the samples were met.

Completeness

Percent completeness (number of valid samples / total number of measurements planned) was 100% (completeness = 156%). Several samples were added to the study in the field and one sample (PGDW27) was not collected as the household shared water from a well that was previously collected (PGDW15). All data points are valid, with the validation qualifiers attached. The completeness is sufficient for the intended purpose.

Comparability

The data are homogeneous for several reasons:

- All samples were collected on the same day, except for PGDW39 (eliminating season and daily variation);
- All samples were collected as specified in the FSP and TSOP (with no deviations); and
- All samples were analyzed using the same methods.

6.0 SUMMARY

The Pavillion Area GW Investigation site is located near Pavillion, Wyoming, in Fremont County. The site is a rural community situated northeast of Pavillion in the Wind River Basin and is centered approximately where several complaints of foul odor and taste in domestic water wells have been raised by residents. Land use surrounding the site is rural, with some residential properties located among fields used for agriculture and oil and gas production. At the direction of the USEPA, START collected groundwater samples from residential and municipal wells in the Pavillion Area Groundwater Investigation site in March 2009.

The VOC contaminant methylene chloride was detected in two groundwater samples at levels above its non-detect value. SVOC contaminants including caprolactam, dimethylphthalate, and bis(2-ethylhexyl)phthalate were detected in groundwater samples at levels above their respective non-detect values. Pesticide contaminants including beta-BHC and endrin aldehyde were detected in groundwater samples at levels above their respective non-detect values, but are in fact false positives.

HPC bacteria, iron related bacteria, and sulfate reducing bacteria were detected in groundwater samples. These may be the cause of foul odor and taste in some cases. Additionally, they may be an indication of groundwater contamination by oil and gas activities or contamination by the water well itself. Many activities in gas well drilling, hydraulic fracturing and work- over's involve injecting water and other fluids into the well and have the potential to create cross-contamination of aquifers. Many states require the addition of sanitizing agents such as bactericides to water used in any down-hole well activities. Wyoming requires that work-over water be from a sanitized drinking water source. Likewise, activities in drinking water wells such as maintenance, and pump replacement can cross-contaminate aquifers as well. DNA fingerprinting could be used to determine which is the case.

Analytical results from the March 2009 sampling events indicated that low levels of metals contamination was consistently detected at levels exceeding non-detect values in samples from the Pavillion Area Groundwater Investigation Site. Arsenic was detected in sample PGDW25 at 34 µg/L, which exceeds the MCL of 10 µg/L.

Elevated levels of TPH were detected in samples PGDW05 and PGDW30 at 26ug/L and 25ug/L respectively.

TIC analyses indicate two compound types that occur in several wells and might not be attributable to well components: adamantanes and 2-butoxyethanol phosphate. Adamantanes are hydrocarbons that occur naturally in crude and gas condensate; they could be used in hydrocarbon fingerprinting analyses to determine if oil and gas production is impacting wells. 2-butoxyethanol is found on the EPA Study List of Drilling Fluid Compounds (EPA 2008) and could react with naturally occurring phosphates to create 2-butoxyethanol phosphate.

Many of the detections (arsenic, methane, adamantanes, 2-butoxyethanol phosphate, and caprolactum) occur in a small number of wells grouped in a relatively small area. This area may benefit from additional investigation.

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Figure 1 Site Location Map

Figure 2 Sample Locations Map

Figure 3 Area of Influence and Well locations

TABLE 6
Sample Locations and Rationale

Matrix	Sample #	Location	Rationale
Domestic well water	PGDW01	Domestic water well.	Identify potential drinking water contaminants.
Domestic well water	PGDW02	Domestic water well.	Identify potential drinking water contaminants.
Domestic well water	PGDW03	Domestic water well.	Identify potential drinking water contaminants.
Domestic well water	PGDW04	Domestic water well.	Identify potential drinking water contaminants.
Domestic well water	PGDW05	Domestic water well.	Identify potential drinking water contaminants.
Domestic well water	PGDW06	Domestic water well.	Identify potential drinking water contaminants.
Municipal well water	PGDW07	Municipal well.	Identify potential drinking water contaminants.
Municipal well water	PGDW08	Municipal well.	Identify potential drinking water contaminants.
Domestic well water	PGDW09	Domestic water well.	Identify potential drinking water contaminants.
Domestic well water	PGDW10	Domestic water well.	Identify potential drinking water contaminants.
Domestic well water	PGDW11	Domestic water well.	Identify potential drinking water contaminants.
Domestic well water	PGDW12	Domestic water well.	Identify potential drinking water contaminants.
Domestic well water	PGDW13	Domestic water well.	Identify potential drinking water contaminants.
Domestic well water	PGDW14	Domestic water well.	Identify potential drinking water contaminants.
Domestic well water	PGDW15	Domestic water well.	Identify potential drinking water contaminants.
Domestic well water	PGDW16	Domestic water well.	Identify potential drinking water contaminants.
Domestic well water	PGDW17	Domestic water well.	Identify potential drinking water contaminants.
Domestic well water	PGDW18	Domestic water well.	Identify potential drinking water contaminants.
Domestic well water	PGDW19	Domestic water well.	Identify potential drinking water contaminants.
Domestic well water	PGDW20	Domestic water well.	Identify potential drinking water contaminants.

TABLE 6
Sample Locations and Rationale

Matrix	Sample #	Location	Rationale
Domestic well water	PGDW21	Domestic water well.	Identify potential drinking water contaminants.
Domestic well water	PGDW22	Domestic water well.	Identify potential drinking water contaminants.
Domestic well water	PGDW23	Domestic water well.	Identify potential drinking water contaminants.
Domestic well water	PGDW24	Domestic water well.	Identify potential drinking water contaminants.
Domestic well water	PGDW25	Domestic water well.	Identify potential drinking water contaminants.
Domestic well water	PGDW25	Domestic water well.	Identify potential drinking water contaminants.
Domestic well water	PGDW26	Domestic water well.	Identify potential drinking water contaminants.
Domestic well water	PGDW27	Domestic water well.	Identify potential drinking water contaminants.
Domestic well water	PGDW28	Domestic water well.	Identify potential drinking water contaminants.
Domestic well water	PGDW29	Domestic water well.	Identify potential drinking water contaminants.
Domestic well water	PGDW30	Domestic water well.	Identify potential drinking water contaminants.
Domestic well water	PGDW31	Domestic water well.	Identify potential drinking water contaminants.
Domestic well water	PGDW32	Domestic water well.	Identify potential drinking water contaminants.
Domestic well water	PGDW33	Domestic water well.	Identify potential drinking water contaminants.
Domestic well water	PGDW34	Domestic water well.	Identify potential drinking water contaminants.
Domestic well water	PGDW35	Domestic water well.	Identify potential drinking water contaminants.
Domestic well water	PGDW36	Domestic water well.	Identify potential drinking water contaminants.
Domestic well water	PGDW37	Domestic water well.	Identify potential drinking water contaminants.
Domestic well water	PGDW38	Domestic water well.	Identify potential drinking water contaminants.
Domestic well water	PGDW39	Domestic water well.	Identify potential drinking water contaminants.
QA/QC	PGDW10D	Field duplicate of sample PGDW10.	Document the precision of sample collection procedures and laboratory analysis.

TABLE 6
Sample Locations and Rationale

Matrix	Sample #	Location	Rationale
QA/QC	PGDW30D	Field duplicate of sample PGDW30. MS/MSD	Document the precision of sample collection procedures and laboratory analysis.
QA/QC	PPTB01	VOC Trip Blank.	Document potential for VOC contamination via transport.

Sample designation - e.g., PG-GW-8: PN = Project name, GW = matrix, 8 = sample number

TABLE 7

Groundwater - Inorganic Sample Results (ICP-MS µg/L)

		SCDM (Drinking Water Benchmarks)			Sample ID												
Analyte	ICP-MS (CRDL)	MCL/ MCLG (µg/L)	RDSC (µg/L)	CRSC (µg/L)	PGDW01	PGDW02	PGDW03	PGDW04	PGDW05	PGDW06	PGDW07	PGDW08	PGDW09	PGDW10	PGDW11	PGDW12	PGDW13
Antimony	2	6	15														
Arsenic	1	10	11	0.057	0.72J	5.4		0.52J					3.7		20.0UJ		
Barium	10	2000	2600		20.0UJ	10.0UJ	10.0UJ	10.0UJ	10.0UJ	10.0UJ	10.0UJ	10.0UJ	10.0UJ	10.9J	2.0UJ	15.8J	15.3J
Beryllium	1	4	73		2.0UJ	1.0UJ	1.0UJ	1.0UJ	1.0UJ	1.0UJ	1.0UJ	1.0UJ	1.0UJ	1.0UJ		1.0UJ	1.0UJ
Cadmium	1	5	18				1.0UJ										
Chromium	2	100	110														
Cobalt	1				0.34J	1.0UJ	1.0UJ	1.0UJ	1.0 UJ	1.0UJ	1.0UJ	1.0UJ	1.0UJ	1.0UJ	0.38J	1.0UJ	1.0UJ
Copper	2	1300			16.3J	5.5J	5.4J	5.7J	5.6J	4.3J	4.5J	7.9J	7.3J	4.0J	10.2J	47.0J	8.2J
Lead	1	15			2.0UJ	1.0UJ	1.0UJ	1.0UJ	1.7J	1.0UJ	1.0UJ	1.0UJ	1.0UJ	1.0UJ	2.0UJ	1.8J	1.0UJ
Manganese	1		5100			2.2	3.4	2.4	3.4		5.6	10.4		4.2		26.7	
Nickel	1		730		4.2J	1.0UJ	1.0UJ	1.0UJ	1.0UJ	1.0UJ	1.0UJ	1.0UJ	1.0UJ	1.0UJ	5.4J	1.0UJ	1.1J
Selenium	5	50	180		28.0J	5.0UJ	5.0UJ	5.0UJ	5.0UJ	5.0UJ	5.0UJ	5.0UJ	9.1J	5.0UJ	10.0UJ	5.0UJ	5.7J
Silver	1		180		2.0UJ	1.0UJ	1.0UJ	1.0UJ	1.0UJ	1.0UJ	1.0UJ	1.0UJ	1.0UJ	1.0UJ	2.0UJ	1.0UJ	1.0UJ
Thallium	1	0.5													0.12J		
Vanadium	1		260		0.2J	42.2							23.3		0.43J		
Zinc	2		11000		8.9J	11.5J	7.6J	11.8J	10.1J	3.6UJ	2.1UJ	2.3UJ	5.1J	17.7J	11.6J	8.3J	42.5J

TABLE 7

Groundwater - Inorganic Sample Results (ICP-MS µg/L)

		SCDM (Drinking Water Benchmarks)			Sample ID												
Analyte	ICP-MS (CRDL)	MCL/ MCLG (µg/L)	RDSC (µg/L)	CRSC (µg/L)	PGDW14	PGDW15	PGDW16	PGDW17	PGDW18	PGDW19	PGDW20	PGDW21	PGDW22	PGDW23	PGDW24	PGDW25	PGDW26
ANTIMONY	2	6	15		2.0UJ	2.0UJ	2.0UJ	2.0UJ					2.0UJ		2.0UJ	2.0UJ	4.0 UJ
ARSENIC	1	10	11	0.057	0.73J	0.55J	0.096	0.50J	0.41J	1.7	0.54J	0.23J	0.95J	0.15J	0.74J	34	0.35J
BARIUM	10	2000	2600		10.0UJ	22.9J	11.0J	8.0J	20.0UJ	18.0J	20.0UJ	10.0UJ	7.6J	11.1J	4.6J	17.8J	9.5J
BERYLLIUM	1	4	73		1.0UJ	0.072J			2.0UJ	1.0UJ	2.0UJ	1.0UJ	1.0UJ	1.0UJ	1.0UJ		
CADMIUM	1	5	18		1.0UJ								0.045J		1.0UJ		0.094J
CHROMIUM	2	100	110		2.0UJ					2.0UJ			2.0UJ		2.0UJ		
COBALT	1				0.18J	0.27J	0.016J	0.031J	0.080J	0.061J	0.073J	0.027J	0.43J	0.023J	0.29J	0.27J	0.54J
COPPER	2	1300			14.8J	12.8	3.9	6.1	7.2J	8.9J	6.9J	26.4J	28.6J	3.7J	16.2J	14	41
LEAD	1	15			2.3J	1.7J	0.55J	1.6J	2.0UJ	1.0UJ	2.0UJ	1.3J	0.24J	1.0UJ	0.29J	1.4J	4.2J
MANGANESE	1		5100		1.5J	68.6	2.9	4	5.1	1.0UJ	35.6	6.7	3.9J	3.9	292J	6.8	157
NICKEL	1		730		1.7J	1.7			2.0UJ	1.0UJ	2.0UJ	1.0UJ	6.5J	1.0UJ	4.4J	1.7	7.3
SELENIUM	5	50	180		14.2J				10.0UJ	5.0UJ	10.0UJ	5.0UJ	6.2J	5.0UJ	5.0UJ	10.7	
SILVER	1		180		1.0UJ				2.0UJ	1.0UJ	2.0UJ	1.0UJ	1.0UJ	1.0UJ	1.0UJ	1.0U	
THALLIUM	1	0.5			0.052J	0.019J							0.027J		1.0UJ	0.019J	0.12J
VANADIUM	1		260		0.58J	1.1J	0.056J	0.033J	0.069J	5.7	0.039J	0.044J	0.31J	0.084J	0.049J	56.7	0.34J
ZINC	2		11000		36.3J	21.9J	54.6J	74.4	4.0UJ	15.0J	6.1J	26.3J	19.4J	7.6J	560J	40.6J	26.9J

TABLE 7

Groundwater - Inorganic Sample Results (ICP-MS µg/L)

		SCDM (Drinking Water Benchmarks) (1/28/2004)			Sample ID											
Analyte	ICP-MS (CRDL)	MCL/ MCLG (µg/L)	RDSC (µg/L)	CRSC (µg/L)	PGDW28	PGDW29	PGDW30	PGDW31	PGDW32	PGDW33	PGDW34	PGDW35	PGDW36	PGDW37	PGDW38	PGDW39
ANTIMONY	2	6	15		2.0UJ	2.0UJ	2.0UJ	4.0 UJ	2.0UJ	2.0UJ	2.0UJ	4.0UJ	2.0UJ	2.0 UJ	2.0UJ	<5
ARSENIC	1	10	11	0.057	0.73J	0.22J	0.094	0.38J	0.56J	0.41J	0.63J	0.62J	0.56J	1.6	2.8	<5
BARIUM	10	2000	2600		16.6J	6.8J	7.9J	7.9J	11.6J	39.7J	7.7J	48.5J	46.9J	31.3J	17.5J	<100
BERYLLIUM	1	4	73								1.0UJ					<1
CADMIUM	1	5	18		0.26J					0.037J	0.036J					1
CHROMIUM	2	100	110								2.0UJ		0.43J			<10
COBALT	1				0.079J	0.024J		0.051J	0.046J	0.45J	0.31J	0.13J	0.12J	0.080J	0.15J	
COPPER	2	1300			5.3	26.3	3.9	9.4	15.2	16	11.9J	9.2	13.5	7.8	11.4	
LEAD	1	15			0.12J	1.3	0.14J	2.0UJ	1.6J	2.2J	0.23J	2.0UJ	0.55J	1.1J	0.63J	
MANGANESE	1		5100		0.38J	6.6	3.3	11.1	12.2	1.8	0.89J	94	0.62J	0.55J	2.2	
NICKEL	1		730							4.5	4.9J		1.9		1.9	<10
SELENIUM	5	50	180		38						25.4J		6.2	8.3	67.3	<5
SILVER	1		180								1.0UJ					
THALLIUM	1	0.5			0.008J					0.020J	0.046J					<5
VANADIUM	1		260		3.3J	0.057J	0.065J	1.3J	0.12J	0.96J	0.57J	0.09J	0.68J	5.8	26.3	
ZINC	2		11000		25.0J	25.3J	35.5J	32.9J	102J	83.6J	28.4J	15.0J	20.9J	81.5J	17.5J	

J Associated numerical value is an estimated quantity and is the approximate concentration of the analyte in the sample.
J+ Associated numerical value is an estimated quantity but the results may be biased high.
J- Associated numerical value is an estimated quantity but the results may be biased low.
UJ The reported quantitation limit is estimated because Quality Control criteria were not met. Element or compound may or may not be present in the sample.
N/A Not applicable.
SCDM Superfund Chemical Data Matrix
RDSC Reference Dose Screening Concentration
CRSC Cancer Risk Screening Concentration
MCLG Maximum Contaminant Level Goal. A non-enforceable health goal that is set at a level at which no known or anticipated adverse effect on the health of persons occurs and which allows an adequate margin of safety.

MCL Maximum Contaminant Level. The highest level of a contaminant that is allowed in drinking water. MCLs are set as close to the MCLG as feasible using the best available analytical and treatment technologies and taking cost into consideration. MCLs are enforceable standards.
CRDL Contract Required Detection Limit (for inorganic analytes).
ICP-MS ICP-Mass Spectrometry

TABLE 8

Groundwater - Inorganic Sample Results (ICP-AES µg/L)

Analyte	ICP-AES (CRDL)	SCDM (Drinking Water Benchmarks)			Sample ID												
		MCL/ MCLG (µg/L)	RDSC (µg/L)	CRSC (µg/L)	PGDW01	PGDW02	PGDW03	PGDW04	PGDW05	PGDW06	PGDW07	PGDW08	PGDW09	PGDW10	PGDW10D	PGDW11	PGDW12
ALUMINUM	200																890
ARSENIC	10	10	11	0.057	10.0UJ	2.8J											
BARIUM	200	2000	2600		13.6J-												
BERYLLIUM	5	4	73														
CADMIUM	5	5	18		0.86J												
CALCIUM	5000				398000	34800	16300	18000	3600J-	7110	8850	36700	16600	6130	6100	363000	7780
CHROMIUM	10	100	110														1.8J-
COBALT	50				4.2J											2.2J-	
COPPER	25	1300			11.8J-	2.6J-							2.3J-			3.7J-	139
IRON	100											283					695
LEAD	10	15															
MAGNESIUM	5000				93600	5320										80900	
MANGANESE	15		5100														18.9
MERCURY	0	2	11		0.077J-												
NICKEL	40		730														
POTASSIUM	5000				6150J	5000UJ	5000UJ	5000UJ	5000UJ	5000UJ	5000UJ	5000UJ	5000UJ	5000UJ	5000UJ	5530J	5000UJ
SELENIUM	35	50	180		35.4J-								8.9J			7.5J-	
SODIUM	5000				808000	85800	272000	270000	192000	249000	213000	390000	233000	204000	204000	423000	256000
VANADIUM	50		260														
ZINC	60		11000		4.1J												
CYANIDE	10	200	730										3.1J-	1.2J-	1.2J-		

TABLE 8

Groundwater - Inorganic Sample Results (ICP-AES µg/L)

Analyte	ICP-AES (CRDL)	SCDM (Drinking Water Benchmarks)			Sample ID												
		MCL/ MCLG (µg/L)	RDSC (µg/L)	CRSC (µg/L)	PGDW13	PGDW14	PGDW15	PGDW16	PGDW17	PGDW18	PGDW19	PGDW20	PGDW21	PGDW22	PGDW23	PGDW24	PGDW25
ALUMINUM	200						480	27.6J	53.2J								125J
ARSENIC	10	10	11	0.057													31
BARIUM	200	2000	2600								16.7J-	9.7J-					
BERYLLIUM	5	4	73														
CADMIUM	5	5	18											0.76J+		0.73J+	
CALCIUM	5000				61000	154000	72200	6420	21200	84500	29000	79300		416000	6510	327000	10900
CHROMIUM	10	100	110														0.58J
COBALT	50													3.2J-		2.8J-	
COPPER	25	1300			4.5J-	5.1J-					5.2J-		1.5J-				
IRON	100						274		20.4J			34.2J				995	51.7J
LEAD	10	15															
MAGNESIUM	5000				19900	18100	10200					9330		126000		131000	
MANGANESE	15		5100				62.6					35.4				302	
MERCURY	0	2	11														
NICKEL	40		730				1.3J-				0.87J-						0.63J-
POTASSIUM	5000				5000UJ	5000UJ	5000UJ	5000UJ	5000UJ	5000UJ	5000UJ	5000UJ	5000UJ	8990J	5000UJ	7020J	5000UJ
SELENIUM	35	50	180		3.5J	12.4J					3J			35.0UJ			
SODIUM	5000				196000	690000	269000	188000	278000	509000	194000	520000	1120J	837000	208000	938000	249000
VANADIUM	50		260											25.0UJ			40.6J
ZINC	60		11000						72.9		15.3J	5.1J	9.4J			769	
CYANIDE	10	200	730		1.6J-	1.2J-		1.3J-			1.4J-			1.5J-			

TABLE 8

Groundwater - Inorganic Sample Results (ICP-AES µg/L)

Analyte	ICP-AES (CRDL)	SCDM (Drinking Water Benchmarks)			Sample ID												
		MCL/ MCLG (µg/L)	RDSC (µg/L)	CRSC (µg/L)	PGDW26	PGDW28	PGDW29	PGDW30	PGDW30D	PGDW31	PGDW32	PGDW33	PGDW34	PGDW35	PGDW36	PGDW37	PGDW38
ALUMINUM	200				64.2J	61J		76J	30.9J	66.3J	54.1J	51.2J	119J	98.4J	49.2J	33.4J	87.1J
ARSENIC	10	10	11	0.057													2.1J
BARIUM	200	2000	2600		8.3J-	14.5J-	5.8J-	6.9J-			9.6J-	35.1J-	6.4J-	44.6J-	42J-		14.6J-
BERYLLIUM	5	4	73										0.47J				
CADMIUM	5	5	18		0.85J+								0.90J+				
CALCIUM	5000				364000	40600	19700	4290J-	4140J-	31200	7160	228000	325000	118000	89500	12100	70000
CHROMIUM	10	100	110														0.65J
COBALT	50				3.1J							2.6J	4.1J				
COPPER	25	1300			38	1.3J	17.7J				6.8J	12.7J			11.8J		5.6J
IRON	100							117			412			1100			18.3J
LEAD	10	15			2.1J												
MAGNESIUM	5000				57700	12900						40900	113000		28900		
MANGANESE	15		5100		137		5.5J	2.6J			8.7J			83			1.2J
MERCURY	0	2	11			0.091J								0.091J			
NICKEL	40		730														
POTASSIUM	5000				6800J	5000UJ	417J	5000UJ	5000UJ	5000UJ	5000UJ	5000UJ	7400J	5000UJ	5000UJ	5000UJ	5000UJ
SELENIUM	35	50	180			37.1						2.8J	18.8J		6.3J		61.8
SODIUM	5000				220000	239000	298000	210000	202000	435000	199000	178000	786000	587000	41700	187000	373000
VANADIUM	50		260			1.9J				0.78J						4.0J	19.5J
ZINC	60		11000						3.8J		82.4	75.1					
CYANIDE	10	200	730						2.2J-					1.4J-			

J Associated numerical value is an estimated quantity and is the approximate concentration of the analyte in the sample.
J+ Associated numerical value is an estimated quantity but the results may be biased high.
J- Associated numerical value is an estimated quantity but the results may be biased low.
UJ The reported quantitation limit is estimated because Quality Control criteria were not met. Element or compound may or may not be present in the sample.
N/A Not applicable.
SCDM Superfund Chemical Data Matrix
RDSC Reference Dose Screening Concentration
CRSC Cancer Risk Screening Concentration
MCLG Maximum Contaminant Level Goal. A non-enforceable health goal that is set at a level at which no known or anticipated adverse effect on the health of persons occurs and which allows an adequate margin of safety.
MCL Maximum Contaminant Level. The highest level of a contaminant that is allowed in drinking water. MCLs are set as close to the MCLG as feasible using the best available analytical and treatment technologies and taking cost into consideration. MCLs are enforceable standards.
CRDL Contract Required Detection Limit (for inorganic analytes).
ICP-AES Inductively Coupled Plasma - Atomic Emission Spectrometry

TABLE 9
Groundwater - Organic Sample Results (µg/L)

			Sample ID							
Analyte	**Ground Water SCDM MCL (ug/L)**	**Drinking Water SCDM MCL (ug/L)**	**PGDW01**	**PGDW02**	**PGDW03**	**PGDW04**	**PGDW05B**	**PGDW07**	**PGDW08**	**PGDW10**
Caprolactam	--	--								
Dimethylphthalate	--	--		1.4J	0.93J	2.7J		1.2J	2.2J	1.5J
Bis(2-ethylhexyl)phthalate	6.0	6.0					2.3J			

			Sample ID							
Analyte	**Ground Water SCDM MCL (ug/L)**	**Drinking Water SCDM MCL (ug/L)**	**PGDW11**	**PGDW12**	**PGDW14**	**PGDW15**	**PGDW18**	**PGDW20**	**PGDW21**	**PGDW22**
Caprolactam	--	--						1.4J		
Dimethylphthalate	--	--								
Bis(2-ethylhexyl)phthalate	6.0	6.0	2J	2.5J	12	1.6J	1.4J	6.4	1.6J	1.4J

			Sample ID						
Analyte	**Ground Water SCDM MCL (ug/L)**	**Drinking Water SCDM MCL (ug/L)**	**PGDW23**	**PGDW25**	**PGDW26**	**PGDW29**	**PGDW31**	**PGDW33**	**PGDW35**
Caprolactam	--	--							
Dimethylphthalate	--	--			1.1J		0.93J	1.3J	
Bis(2-ethylhexyl)phthalate	6.0	6.0	2.1J	**9.8**		1.8J			3.1J

Bold Analyte detected above method detection limit

SCDM Superfund Chemical Data Matrix

MCL Maximum Contaminant Level. The highest level of a contaminant that is allowed in drinking water. MCLs are set as close to the MCLG as feasible using the best available analytical and treatment technologies and taking cost into consideration. MCLs are enforceable standards.

TABLE 10

Groundwater – Petroleum Hydrocarbon Results

Analyte	Unit	MCL	PGDW05	PGDW30
Gasoline Range Organics (GRO)	µg/L	NA	ND	ND
GRO as Gasoline	µg/L	NA	ND	ND
Total Purgeable Hydrocarbons (TPH)	µg/L	NA	**26**	**25**
Diesel Range Organics (DRO)	mg/L	NA	ND	ND
DRO as Diesel	mg/L	NA	ND	ND
Total Extractable Hydrocarbons	mg/L	NA	ND	ND

Bold	Analyte detected above method detection limit
SCDM	Superfund Chemical Data Matrix
MCL	Maximum Contaminant Level. The highest level of a contaminant that is allowed in drinking water. MCLs are set as close to the MCLG as feasible using the best available analytical and treatment technologies and taking cost into consideration. MCLs are enforceable standards.
N/A	Not applicable.

TABLE 11

Groundwater – Microbacteriological Sample Results

Analyte	Unit	MCL	PGDW04	PGDW05	PGDW20	PGDW22	PGDW22B	PGDW23
Bacteria, HPC	MPN/ml	NA	**21**	**130**	ND	ND	**2**	ND
Bacteria, Iron Related	CFU/ml	NA	**present**	**present**	ND	ND	**present**	ND
Bacteria, Sulfate Reducing	CFU/ml	NA	ND	**present**	ND	ND	ND	ND

N/A	Not applicable.
Bold	Analyte detected above method detection limit
SCDM	Superfund Chemical Data Matrix
MCL	Maximum Contaminant Level. The highest level of a contaminant that is allowed in drinking water. MCLs are set as close to the MCLG as feasible using the best available analytical and treatment technologies and taking cost into consideration. MCLs are enforceable standards.

TABLE 12
Groundwater - Anion and Water Chemistry Sample Results (µg/L)

Analyte	CAS Number	MCL or Secondary Standard	PGDW01	PGDW02	PGDW03	PGDW04	PGDW05	PGDW06	PGDW07	PGDW08	PGDW09	PGDW10	PGDW11	PGDW12	PGDW13
Alkalinity	NA	NA	234	108	39.5	28.7	93.3	34.9	60.6	82.9	254	147	312	37.1	303
Chloride	16887-00-6	250*	34.3	2.6	25.1	21.6	17	31	15.7	8.9	10.5	8	15.3	30.8	6.2
Fluoride	16984-48-8	2	0.4	0.7	0.9	0.9	0.9	1.3	1.2	0.5	2.4	0.9	0.2	1.5	0.7
Nitrate as N	NA	10	6.2	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	3.2	<0.5	1.3	<0.5	1
Nitrite as N	NA	1	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Sulfate as SO4	148-08-798	250*	**1860**	175	**549**	**551**	**295**	**485**	**390**	**857**	**279**	**293**	**1780**	**497**	**343**

Analyte	CAS Number	MCL or Secondary Standard	PGDW14	PGDW15	PGDW16	PGDW17	PGDW18	PGDW19	PGDW20	PGDW21	PGDW22	PGDW23	PGDW24	PGDW25	PGDW26
Alkalinity	NA	NA	159	277	145	21.2	20.5	291	70.2	<5.00	332	61.4	165	205	337
Chloride	16887-00-6	250*	26.1	9.9	13.4	49.5	27	6.9	34.5	0.6	79.9	19.8	55.7	8.4	14.6
Fluoride	16984-48-8	2	0.4	0.6	0.8	2	1.8	0.9	0.8	<0.2	<0.2	1.2	0.6	4.1	0.7
Nitrate as N	NA	10	0.7	1.8	<0.5	<0.5	0.5	2.6	<0.5	<0.5	**43.6**	<0.5	<0.5	<0.5	1.5
Nitrite as N	NA	1	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Sulfate as SO4	148-08-798	250*	**1820**	**520**	**258**	**583**	**1380**	196	**1370**	<1.0	**2720**	**365**	**3200**	**355**	**1240**

Analyte	CAS Number	MCL or Secondary Standard	PGDW28	PGDW29	PGDW30	PGDW31	PGDW32	PGDW33	PGDW34	PGDW35	PGDW36	PGDW37	PGDW38	PGDW39
Alkalinity	NA	NA	258	52.3	95.7	82.5	34.1	276	373	84	232	342	46.9	127
Chloride	16887-00-6	250*	16.7	24.6	16.3	13.3	21.8	23	28	24.1	3.2	8.7	33.7	48
Fluoride	16984-48-8	2	0.5	0.9	0.9	0.4	2.3	0.2	0.5	0.3	1	0.9	1.3	0.4
Nitrate as N	NA	10	3.7	<0.5	<0.5	0.5	<0.5	2.1	3.5	0.5	1.2	1.2	5.9	0.6
Nitrite as N	NA	1	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Sulfate as SO4	148-08-798	250*	**298**	**596**	**335**	**1030**	**373**	**2690**	**670**	**1610**	195	89.9	**908**	**3980**

Bold Result exceeds benchmark.

* Secondary Drinking Water Standards (these limits are not controlled on, but rather a guide for color and taste).

N/A Not applicable.

MCL Maximum Contaminant Level. The highest level of a contaminant that is allowed in drinking water. MCLs are set as close to the MCLG as feasible using the best available analytical and treatment technologies and taking cost into consideration. MCLs are enforceable standards.

TABLE 13

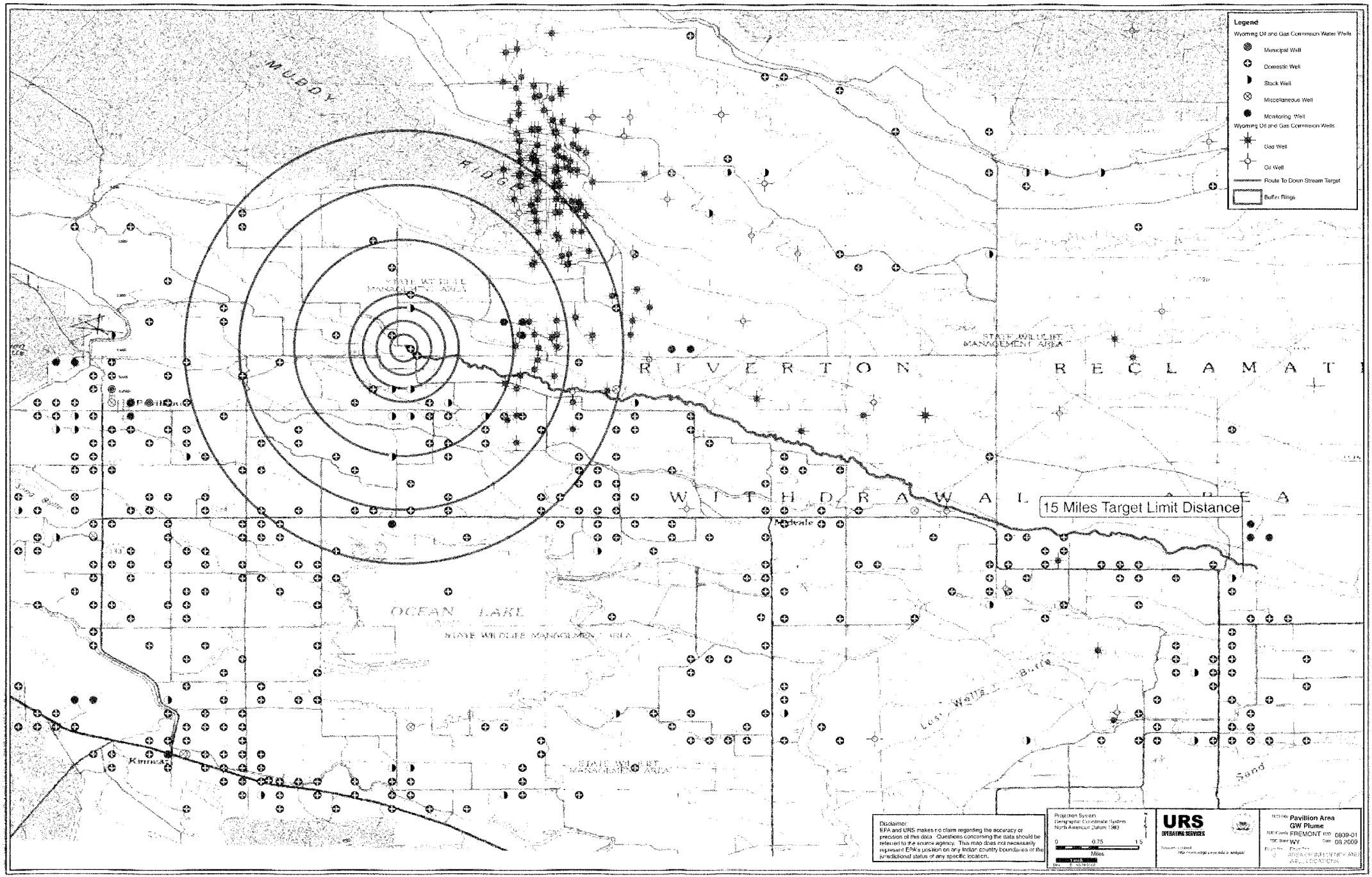
Groundwater - Methane Results

Sample ID	Methane (µg/L)
PGDW05	16.6
PGDW17	10.6
PGDW20	137
PGDW21	54.3
PGDW23	146
PGDW30	558
PGDW32	21.4
PGDW35	21.6

TABLE 14

Groundwater – Tentatively Identified Compounds (SVOC and VOC) Sample Results

TIC Compound	Sample
Adamantanes	PGDW05
	PGDW20
	PGDW30
2-Butoxyethanol Phosphate	PGDW04
	PGDW10
	PGDW25
2,4-bis(1-phenyl)-phenol	PGDW23
Bisphenol A	PGDW05
Terpineol	PGDW20
5-Hydroxymethyldihydrofuran	PGDW20
Limonene	PGDW03



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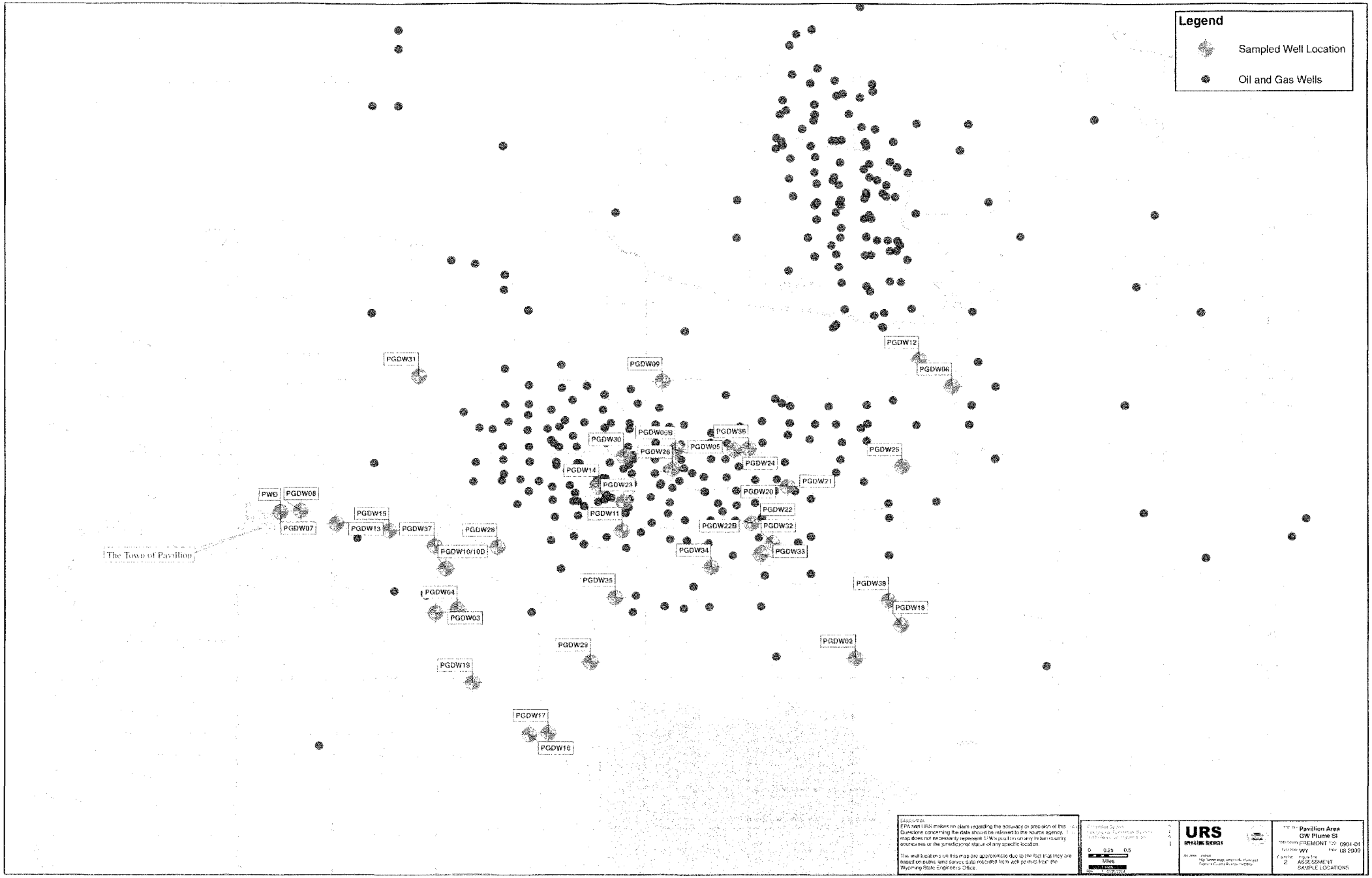

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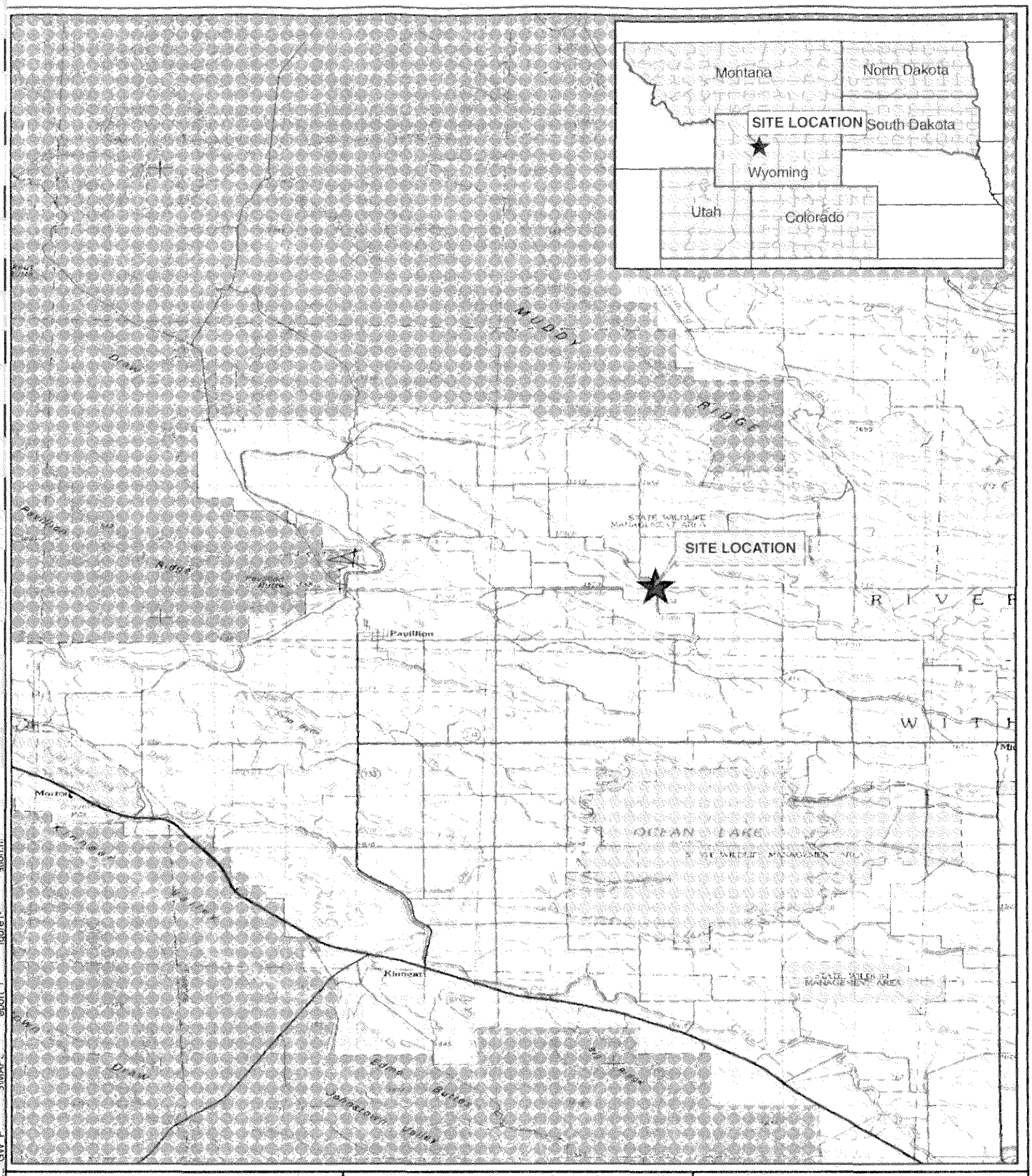

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TDD Title: **PAVILLION AREA GW PLUME**

TDD County: FREMONT TDD: 0901-01

TDD State: WY Date: 08 2009

Figure No. 1 Figure Title: Site Location Map

EPAPAV0118201